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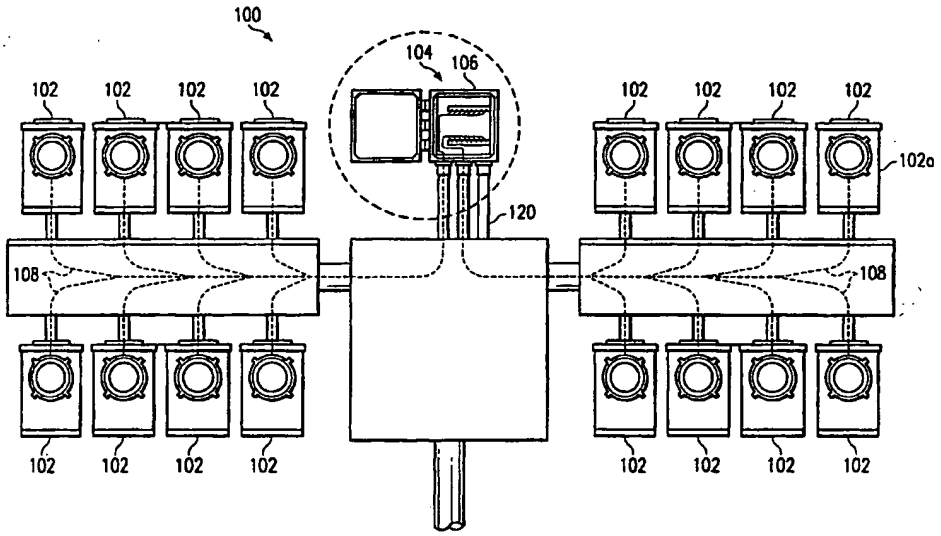
(54) Title: SYSTEM AND METHOD FOR REMOTELY READING UTILITY METERS



(57) Abstract: A system and method for remotely reading unitility meters. The system may include a plurality of meter readers (110). Each of the meter readers may be operable to couple to a respective utility meter (102) and may be further operable to communicate a usage signal indicating utility flow through the respective utility meter. The system may also include a remote collector (114) communicatively coupled to the plurality of meter readers. The remote collector may be operable to receive usage signals from the plurality of meter readers, to convert the usage signals into usage data, and to store the usage data. The system may also include a transmission device (124) communicatively coupled to the remote collector. The transmission device may be operable to transmit the stored usage data via cellular transmission.

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SYSTEM AND METHOD FOR REMOTELY READING UTILITY METERS

TECHNICAL FIELD OF THE INVENTION

The present disclosure relates in general to the field of information gathering, and more particularly to a system and method for remotely reading utility meters.

BACKGROUND OF THE INVENTION

In today's world of immediate access through online services, utility providers as well as utility consumers are demanding a better accounting of utility usage and cost data. Conventional accounting techniques employed by utility providers, such as local electric, water, or gas companies, are often inefficient, time consuming, and expensive.

For example, a typical and longstanding method of determining how much energy a consumer of electricity uses during a given time period involves the sending of an electric company employee to the consumer's home or business where an individual meter may be read. This process may require thousands of man-hours every reporting cycle. An employee may regularly visit several accounts in order to read the amount of energy consumed by each of the several accounts. These readings, which may be, for example, monthly, are often difficult to obtain because of such things as dangerous neighborhoods, unfriendly pets, and meters in inaccessible locations.

Another problem facing manual meter reading is off-cycle meter reads. Generally, the process of manual meter reading relies on distributing meter reading costs across many accounts. When a single meter needs to be read off-cycle, efficiencies of scale can be lost. This may be seen, for example, in multi-tenant buildings, such as an apartment building. These buildings tend to have frequent move-in/move-outs requiring off-cycle meter reads or special trips to read meters.

Some utility providers are beginning to use specialized devices that allow for automated meter reading. Several companies manufacture such devices. For example, American Innovations, located in Austin, Texas, manufactures a device that attaches to a utility meter at a consumer's premises and communicates with a utility provider (e.g., a local electric company) via landline. In most cases, the landline may

be the telephone line providing service to the consumer's premises. The device in the meter tracks and stores the utility usage and, on a regular basis, sends the usage data to the utility provider or a system manager collecting usage data for the utility provider via the landline. As such, the utility provider may no longer need to send an employee out every month to read a meter.

Utility companies have also automated the reading of meters with wireless systems. This approach alleviates the need for a landline, but implementation of the system may be relatively expensive especially for sporadic coverage of meters since a wireless backbone system must generally be installed for the entire coverage area. Alternatively, an existing wireless system may be used, but this usually requires a relatively expensive device capable of two-way cellular communication to be installed in every meter to be read remotely and data transmission rates are not typically cost effective. The costs associated with installing this system may be prohibitive, especially when applying it as needed instead of en masse.

SUMMARY OF THE INVENTION

In accordance with teachings of the present disclosure, a system and method for remotely reading utility usage from utility meters are disclosed that provide significant advantages over prior developed systems. The disclosed embodiments allow a utility provider to accurately and efficiently track, report, and bill for a consumer's utility usage.

According to one aspect of the present disclosure, a system incorporating teachings of the present invention may include, for example, a plurality of meter readers. Each of the meter readers may be operable to couple to a respective utility meter and may be further operable to communicate a usage signal indicating utility flow through the respective utility meter. The system may also include a remote collector communicatively coupled to the plurality of meter readers. The remote collector may be operable to receive usage signals from the plurality of meter readers, to convert the usage signals into usage data, and to store the usage data. The system may also include a transmission device communicatively coupled to the remote collector. The transmission device may be operable to transmit the stored usage data via cellular transmission.

According to another aspect of the present disclosure, a meter reading system for remotely reading meters may, in operation, transmit a first utility usage signal from a first meter reader to a remote collector. The operation may also include transmitting a second utility usage signal from a second utility meter reader to the remote collector. Each of these usage signals may be converted into utility usage data for the respective utility meters. This usage data may be stored at the remote collector. This storage may, in some embodiments, represent the first time usage data is stored.

In addition, the stored utility usage data may be transmitted from the remote collector with a transmission device communicatively coupled to the remote collector. The transmission device may transmit the stored utility usage data via an existing cellular network. As such, the disclosed embodiments may be less costly to implement.

In addition to lowering implementation costs, the disclosed embodiments will preferably allow for efficient and cost-effective automated meter reading for both on-cycle and off-cycle utility meter reads. This may be especially important in areas with dense populations of utility meters such as multi-tenant buildings, which often require expensive off-cycle meter reads.

In addition, because the system may require only one communication device and one storage for numerous meters, the equipment costs of remotely reading utility meters from a bank of meters may be reduced.

Other technical advantages will be apparent to those of ordinary skill in the art in view of the following specification, claims, and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features, and wherein:

FIGURES 1A-1D depict components of an embodiment of a system for remotely reading a bank of utility meters;

FIGURE 2 depicts an embodiment of a remote collector, which may be a component of a system for remotely reading utility meters;

FIGURE 3 depicts an internal view of an embodiment of a housing with a remote collector and a transmission device placed within a housing;

FIGURE 4 shows an embodiment of a transmission device mounted within a housing;

FIGURE 5 shows a flow diagram depicting an embodiment of a method for remotely reading utility meters on a pre-set or regular basis; and

FIGURE 6 shows a flow diagram depicting an embodiment of a method for remotely reading utility meters on a special or off-cycle basis.

DETAILED DESCRIPTION OF THE INVENTION

FIGURE 1A depicts an embodiment of a system representatively depicted at 100 for remotely reading a bank of utility meters. As depicted, system 100 may be located at a mounting wall of a multiple tenant facility, which may include any number of buildings. For illustrative purposes, the meter mounting wall includes a bank of sixteen utility meters 102. However, a system incorporating teachings of the present invention may incorporate any number of utility meters. Meters 102 may be connected to remote collector 104 by respective communication lines 108, which may be seen in FIGURE 1B. Communication lines 108 may be made from any suitable type of communication line. For example, communication lines 108 may be three-wire KYZ dry contact closure communication lines. In some embodiments, communication lines 108 may include fiber optic cables.

Meters 102 may be utility meters and could be, for example, electric meters, gas meters, or water meters. Attached to the terminal ends of communication line 108 may be respective meter readers 110, depicted in FIGURE 1C. Meter readers 110 may interface with meters 102 via an interface output such as a standard KYZ output or an Optical Pulse Initiator (OPI) manufactured by American Innovations. Meter reader 110 may be installed in a respective meter 102 in order to count or track the utility usage and send a usage signal representing utility usage back to remote collector 114, shown in FIGURE 1B, via communication line 108, which is also shown in FIGURE 1B.

For exemplary purposes, in FIGURE 1C, meter 102a is shown in an exploded and expanded view as having a utility usage tracking device 112. Utility usage tracking device 112 may be part of a utility meter and may provide a visual indication of how much of a utility such as electricity has been used, has passed through meter 102a. In an electric meter, a rotating disk with a black marking on its surface may be used as a usage tracking device. By counting the number of times the black marking passes, indicating revolutions made by the disk, a counter may keep track of how much electricity has passed through the utility meter. Meter reader 110 of FIGURE 1C may be installed inside meter 102a to monitor utility usage tracking device 112 and track how much of a utility is being used.

Each communication line 108 leaves a respective meter such as meter 102a and enters into housing 106, shown in FIGURE 1A. Once inside housing 106, each communication line 108 may terminate at and connect to remote collector 114, shown in FIGURE 1B. Remote collector 114 may include a terminal connector board 116, shown in FIGURE 1B and screw terminal connectors 118, also shown in FIGURE 1B. Communication lines 108 may enter through the bottom of housing 106 and attach to remote collector 114 via screw terminal connectors 118.

Located within housing 106 and behind remote collector 114 may be power supply input 122, shown in FIGURE 1D, and transmission device 124, also shown in FIGURE 1D. The elements within housing 106 may make up collector box 104 and may be powered with AC electricity supplied by AC power line 120 as shown in FIGURE 1A. AC power line 120 may enter through the bottom of housing 106 and terminate at power supply input 122, shown in FIGURE 1D. In some embodiments, externally supplied AC power may be replaced with other suitable power supplies. For example, some embodiments may be, at least occasionally powered by lithium batteries, other suitable batteries, or a solar/battery power combination.

As depicted in FIGURE 1D, transmission device 124 may be a cellular radio such as the SKYLEMETRY AMR6 manufactured by PGI International of Houston, Texas. Transmission device 124 may transmit utility usage data using cellular communication such as MICROBURST technology.

Aeris Corporation offers MICROBURST as a low cost alternative for sending small data packets of information over an existing cellular network. This technology

may use digital control channels of existing cellular networks to send fifteen digit data packets. The control channel typically has less traffic and higher power than the voice channels and allows for more robust operation. In fact, MICROBURST may be available in areas where cellular voice service may not be available.

MICROBURST transmissions tend to be cost-effective because the data packets are sent over an established cellular telephone infrastructure and the signaling and messaging operate anywhere Advanced Mobile Phone Service (AMPS) is available. Because the control channels and not the voice channels of the cellular network are employed, MICROBURST transmissions generally operate within and transparent to an existing cellular infrastructure. Because of this transparent operation within an established network, expensive initial outlays or expensive upgrades may not be necessary to utilize the technology. As such, control channel cellular communications may be less expensive than other forms of cellular communication.

In operation, control channel cellular communications may transmit data packets of information within the control channels of a cellular network using standard IS-41 signaling mechanisms and standard message protocols according to EIA/TIA-553 specifications. Typically, the signals may be sent and received with a single device. The Reverse Control Channel (RECC) may be used when sending data from the device, such as transmission device 124, and the Forward Control Channel (FOCC) may be used when sending data requests from a host control channel to a transmission device.

Meter reader 110, installed within each meter 102, may observe utility usage and pass usage signals via communications lines 108 to remote collector 114. In one embodiment, meter reader 110 could be designed without data storage capacity making it unable to store utility usage data. In this embodiment, meter reader 110 would merely monitor utility usage tracking device 112. Every time meter 102 recognizes a certain utility usage milestone, such as a complete revolution of utility usage tracking device 112, meter reader 110 would send a signal through communication lines 108 to remote collector 114. In this way, meter reader 110 may communicate the milestone and thereby allow remote controller 114 to convert the utility usage milestone into stored utility usage data. Communicatively coupled to remote collector 114 may be transmission device 124, which may occasionally access

the utility usage data stored in remote collector 114 on a selected periodic cycle or as required on an off cycle basis and communicate the stored utility usage via cellular communication.

FIGURE 2 depicts a detailed representation of remote collector 114. As depicted in FIGURE 2, remote collector 114 may be enclosed in housing 106 and may be include a terminal connector board 116 and screw terminal connectors 118. Housing 106 may be a single enclosure and be NEMA 4, weatherproof, and tamper resistant. The tamper resistance characteristic may be very important, because housing 106 encloses components of the present invention, which may be responsible for utility readings used to calculate a customer's bill. Housing 106 may include door 206 attached to housing 106 by hinges or other suitable means. Housing 106 may be designed to mount externally on a wall or conduit near a bank of meters 102 in order to enable remote collector 114 to store utility usage data from a number of meters.

Attached to underside 208 of housing 106 may be three inputs for communication lines or power supply lines. There may be two communication line inputs 202 and one power input 204 or any other suitable combination.

Communication lines 108 may enter into housing 106 via communication inputs 202 and continue on and connect to terminal connector board 116 using screw terminal connectors 118. Terminal connector board 116 may have at least as many screw terminal connectors 118 as are needed to interface with the number of meters in the meter bank. For example, FIGURE 2 shows a terminal connector board 116 with two rows of screw terminal connectors 118 able to support up to sixteen different utility meters. Screw terminal connectors 118 support inputs from OPI or other utility meter KYZ output including Form A contact closures, pulse outputs from water meters, or any other suitable type of output.

In a preferred embodiment, remote collector 114 will not require inputs into all screw terminal connectors 118 or require inputs to specific screw terminal connectors 118 in order to operate.

FIGURE 3 depicts an expanded view of housing 106 illustrating how the remote collector 114 and transmission device 124 may be placed within housing 106. Terminal connector board 116 of remote collector 114 may be mounted near the front of housing 106 on hinge supports 302 and supports 304. By mounting terminal

connector board 116 on hinge supports 302 and supports 304, there may be room in the rear portion of housing 106 for such components as transmission device 124. Terminal connector board 116 may be operable to rotate from zero to ninety degrees in order to allow access to the components mounted behind terminal connector board 116. Hinge supports 302 may connect remote collector 114 to housing 106 and allow for ninety-degree rotation of terminal connector board 116, which may reveal transmission device 124 below.

FIGURE 4 shows transmission device 124 mounted within housing 106. Terminal connector board 116, now in an open or ninety-degree position, allows access to components behind remote collector 114. Mounted against controller board 402 may be an additional power supply 404, power supply input 122, and transmission device 124. Power supply line 120 (not shown in FIGURE 4) may enter housing 106 through power input 204 and may connect to power supply input 122. In one embodiment, power supply input 122 can allow for collector box 104 to be powered by externally supplied AC power via power supply line 120.

Transmission device 124, which may be essentially a radio device suitable for wireless communication, may be communicatively coupled to remote collector 114 and operable to transmit utility usage data to a database.

Meter reader 110 (shown in FIGURE 1C) may be equipped with a sensor operable to provide a usage signal (e.g., a pulse) to remote collector 114. Remote collector 114 may then convert the signal into utility usage data and store that utility usage data. Transmission device 124 may be designed to access the stored utility usage data and to transmit it in up to six digits of index resolution. For cost-effective monitoring of meters and to conserve battery power if battery power is the power source of choice, transmission device 124 may be powered on only during the short transmission period.

FIGURE 5 shows a flow diagram depicting system 500 and associated method for remotely reading utility meters on a pre-set or regular basis. At step 502, a database may automatically query a database server and requests a monthly meter read for all the meters connected to a collector box (e.g., collector box 104). This request may be based on a pre-set reporting cycle. This pre-set cycle may be daily, weekly, monthly, yearly, or any other regular basis as desired by the utility provider.

In one embodiment, the utility provider to whom the meters belong may freely arrange and/or change the pre-set reporting cycle. In a preferred embodiment, the utility provider may be able to access a database server, the database, and the pre-set schedule using a secure TCP/IP connection over the Internet. In step 504, the database server forwards the request from the database to a host server using, for example, a secure TCP/IP connection over the Internet.

The request may prompt the host server to page the primary mobile identification number (MIN) for a given collector box's (e.g., collector box 104) transmission device (e.g., transmission device 124). In a preferred embodiment, the transmission device may have at least one unique MIN with a Number Plan Area (NPA) field set to 175. By using an NPA of 175, the transmissions may be recognizable by the Signaling System 7 (SS7) network as a transmission that should avoid voice cellular frequencies. Typically, an NPA of 175 cannot be used by traditional voice calls.

After the host server receives the request, in step 506, the host server may forward the request via the SS7 network. The host server may access a roamer port set up on a switch and provide it with the proper MIN for a given transmission device. This may allow the switch to send a cellular page to the transmission device and trigger the transmission device to transmit the requested utility usage data.

When transmitted over the cellular network, the page may be received at step 508 by a collector box (e.g., collector box 104 of FIGURE 1). After receiving the request, the transmission device within the collector box may begin to respond to the request by transmitting, at step 510, stored utility usage data in a series of data packets. The data packets may contain utility usage data for one or more meters per transmission. In one embodiment, the data packets may consist of two five digit meter reads, a meter port location, and a type indicator. The type indicator indicates whether the meter read is a pre-set cycle read, a special and off-cycle read, a test read, or a demand peak read. The data packet can be a sixteen digit array with the first digit being an "*" followed by the port location N, a five digit meter reading for port location N, a two digit reserved space, a five digit meter reading for port location N+1, a read indicator type, and one final digit reserved for future use. Other packet

configurations may be used. For example, each packet may allow for reading as many as eight or more meters.

In step 512, the data packets may be received by the cellular network and forwarded over the SS7 network to the host server. When the data packets are received at the host server, the MIN, a meter identifier (e.g., the meter's Electronic Serial Number (ESN)), and utility usage data are extracted from the data packet. The host server may then determine the destination of the data. In step 514, the host server may forward the data extracts using a secure TCP/IP connection over the Internet to the database server. At step 516, the database server may then format the data extracts and store the formatted data extracts in the database.

The data extracts might at step 518 be transmitted to the utility server via electronic mail or the Internet. The data may also, at step 520, be stored in a utility provider database where it can be easily accessed by the utility provider in step 522.

FIGURE 6 shows a flow diagram depicting system 600 and associated method for remotely reading utility meters on a special or off-cycle basis as desired by the utility provider. System 600 differs from system 500 in that system 600 may be employed when requesting utility usage data in special off-cycle circumstances, for example, in instances where a party moves in or moves out of a property after the pre-set cycle readings have been transmitted.

In step 602, a utility provider or user may request a special off-cycle reading of a meter. At step 604, a utility server may send a request to a database server via electronic mail or a secure TCP/IP connection over the Internet. At step 606, the database server may query a database to determine the correct MIN for the collector box connected to the meter to be read. The database, at step 608, may forward the correct MIN to the database server and the database server may send, at step 610 the request to a host server over a secure TCP/IP connection on the Internet. After the host server receives the request, in step 612, the method of 600 may closely track method 500 of FIGURE 5.

A page may be sent via a cellular network and received at step 614 by a collector box (e.g., collector box 104 of FIGURE 1). After receiving the request, a transmission device within the collector box may begin to respond to the request by transmitting, at step 616, stored utility usage data in a series of data packets. In step

618, the data packets may be received by the cellular network and forwarded over the SS7 network to the host server. When the data packets are received at the host server, the MIN, a meter identifier (e.g., the meter's Electronic Serial Number (ESN)), and utility usage data may be extracted from the data packet. The host server may also determine the destination of the data. In step 620, the host server may forward the data extracts using a secure TCP/IP connection over the Internet to the database server. At step 622, the database server may format the data extracts and store the formatted data extracts in the database.

The data extracts may also at step 624 be transmitted to the utility server via electronic mail or the Internet. The data may also, at step 626, be stored in a utility provider database where it can be easily accessed by the requesting utility provider or user in step 628.

Although the disclosed embodiments have been described in detail, it should be understood that various changes, substitutions and alterations can be made to the embodiments without departing from their spirit and scope.

WHAT IS CLAIMED IS:

1. A system for remotely reading utility meters, the system comprising:

a plurality of meter readers, each of the plurality of meter readers operable to couple with a respective utility meter and provide a usage signal indicating utility flow through the respective utility meter;

a remote collector communicatively coupled to the plurality of meter readers, the remote collector operable to receive the respective usage signals, convert the usage signals into respective usage data, and to store the respective usage data; and

a transmission device communicatively coupled to the remote collector and operable to transmit the stored usage data via cellular transmission.

2. The system of Claim 1, further comprising the remote collector communicatively coupled to sixteen meter readers.

3. The system of Claim 1, further comprising the transmission device operable to transmit the stored usage data within a control channel of a cellular network.

4. The system of Claim 1, further comprising the transmission device operable to send and receive cellular transmissions.

5. The system of Claim 1, further comprising each of the meter readers operable to monitor a utility usage tracking device located within each meter reader's respective utility meter.

6. The system of Claim 5, wherein the utility usage tracking device comprises a rotatable disk.

7. The system of Claim 1 further comprising a plurality of direct link communication cables, each of the plurality of cables communicatively coupling the remote collector to one of the meter readers.

8. The system of Claim 1 further comprising a conversion table storing an appropriate conversion factor for converting respective usage signals from the meter readers into accurate usage data for each meter readers' respective utility meter.

9. The system of Claim 1, further comprising at least one of the plurality of meter readers operable to couple to its respective utility meter within a portion of the respective utility meter's housing.

10. A method for remotely reading meters, comprising:

transmitting a first utility usage signal from a first meter reader to a remote collector;

transmitting a second utility usage signal from a second utility meter reader to the remote collector;

converting the first utility usage signal into utility usage data for the first utility meter;

converting the second utility usage signal into utility usage data for the second utility meter; and

storing the utility usage data for the first utility meter and the utility usage data for second utility meter at the remote collector.

11. The method of Claim 10, further comprising transmitting the stored utility usage data from the remote collector with a transmission device communicatively coupled to the remote collector.

12. The method of Claim 11, further comprising transmitting the stored utility usage data via a cellular network.

13. The method of Claim 12, further comprising transmitting the stored utility usage within a control channel of a cellular network.

14. The method of Claim 10, further comprising initially storing utility usage data for at least sixteen different utility meters in the remote collector.

15. The method of Claim 10, further comprising:
sending a request for stored utility usage data to the transmission device; and
transmitting the stored utility usage data in response to the request.

16. The method of Claim 15, further comprising periodically sending a request for utility usage data.

17. The method of Claim 15, further comprising:
receiving the transmitted utility usage data;
maintaining a database with the transmitted utility usage data; and
accessing the database accessible the Internet.

18. The method of Claim 17, further comprising:
creating a schedule containing times for requesting stored utility usage data;
sending requests for stored utility usage data in accordance with the schedule; and
modifying the schedule via the Internet.

19. A system for remotely reading electric utility meters located at a multiple tenant facility, comprising:

a plurality of meter readers, each of the plurality of meter readers operable to monitor a respective electric utility meter and further operable to send a respective usage signal to a remote collector indicating utility usage through the respective utility meter;

the remote collector communicatively coupled to the plurality of meter readers, the remote collector operable to receive the respective usage signal from each of the plurality of meter readers and to convert the respective usage signals into respective electric utility usage data for each electric utility meter, the remote collector further operable to store the respective electric utility usage data; and

a cellular based transmission device communicatively coupled to the remote collector and operable to transmit the stored electric utility usage data via cellular transmission.

20. The system of Claim 19, further comprising the remote collector operable to receive signals from and store data for at least sixteen meter readers.

21. The system of Claim 19, further comprising the transmission device operable to transmit the electric utility usage data within a control channel of a cellular network.

FIG. 1A

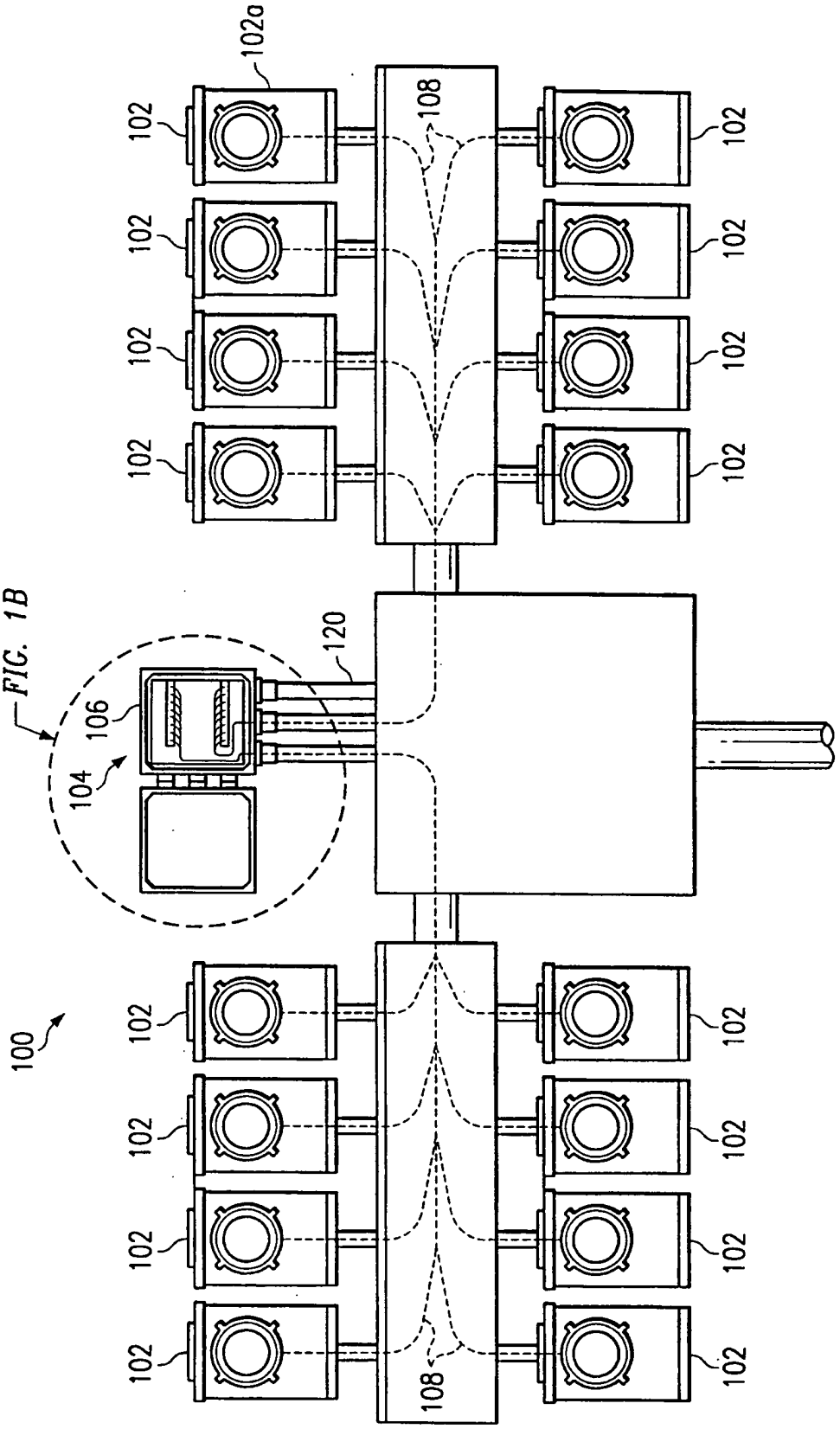


FIG. 1B

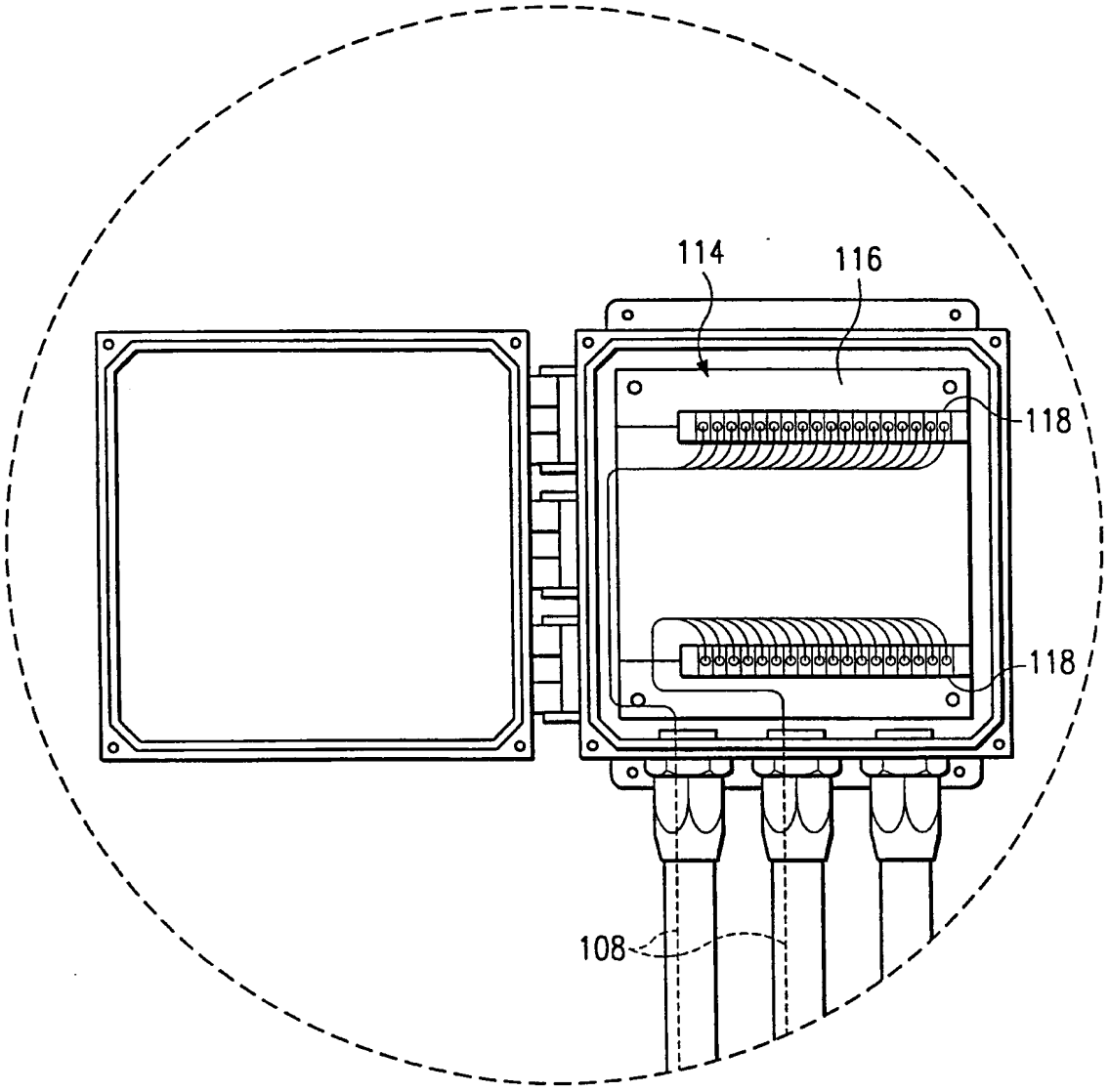


FIG. 1C

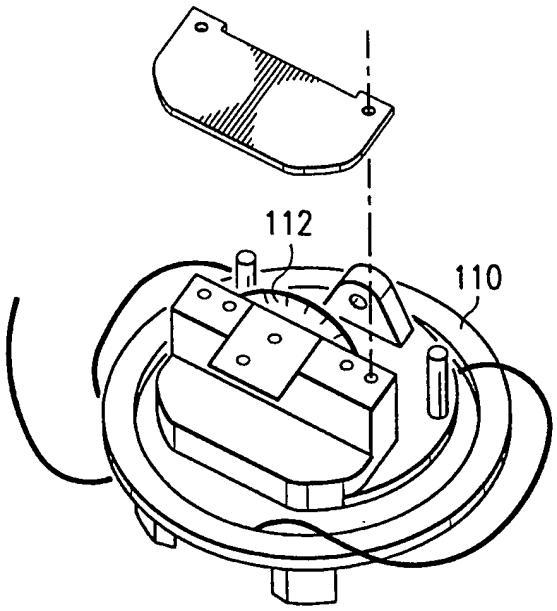
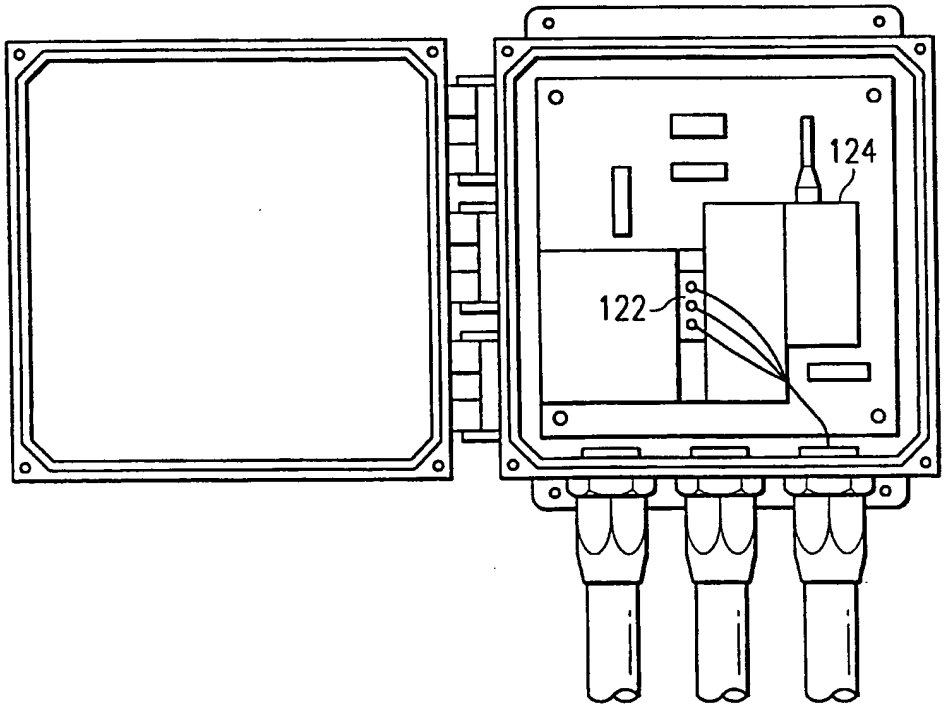


FIG. 1D



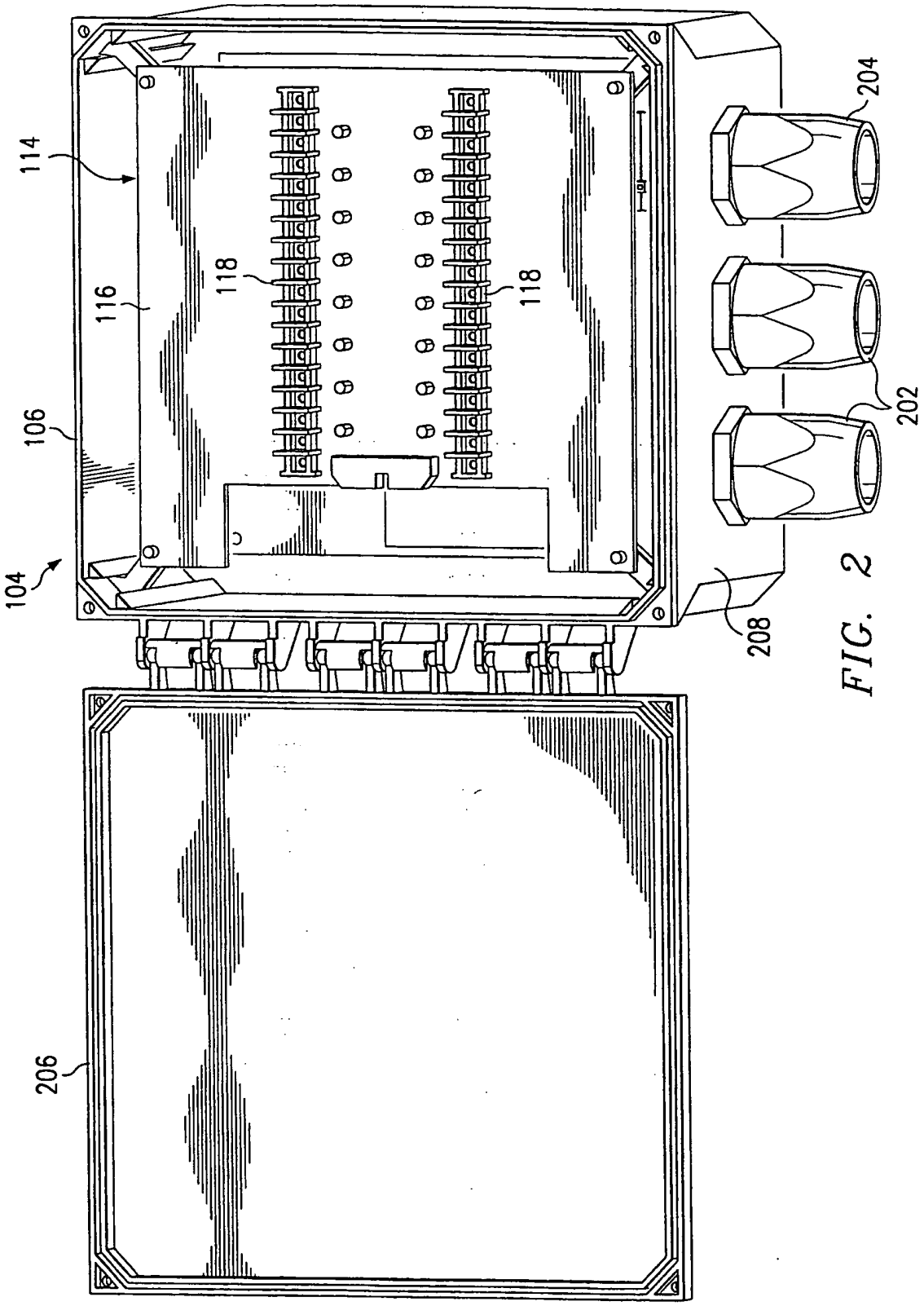


FIG. 2

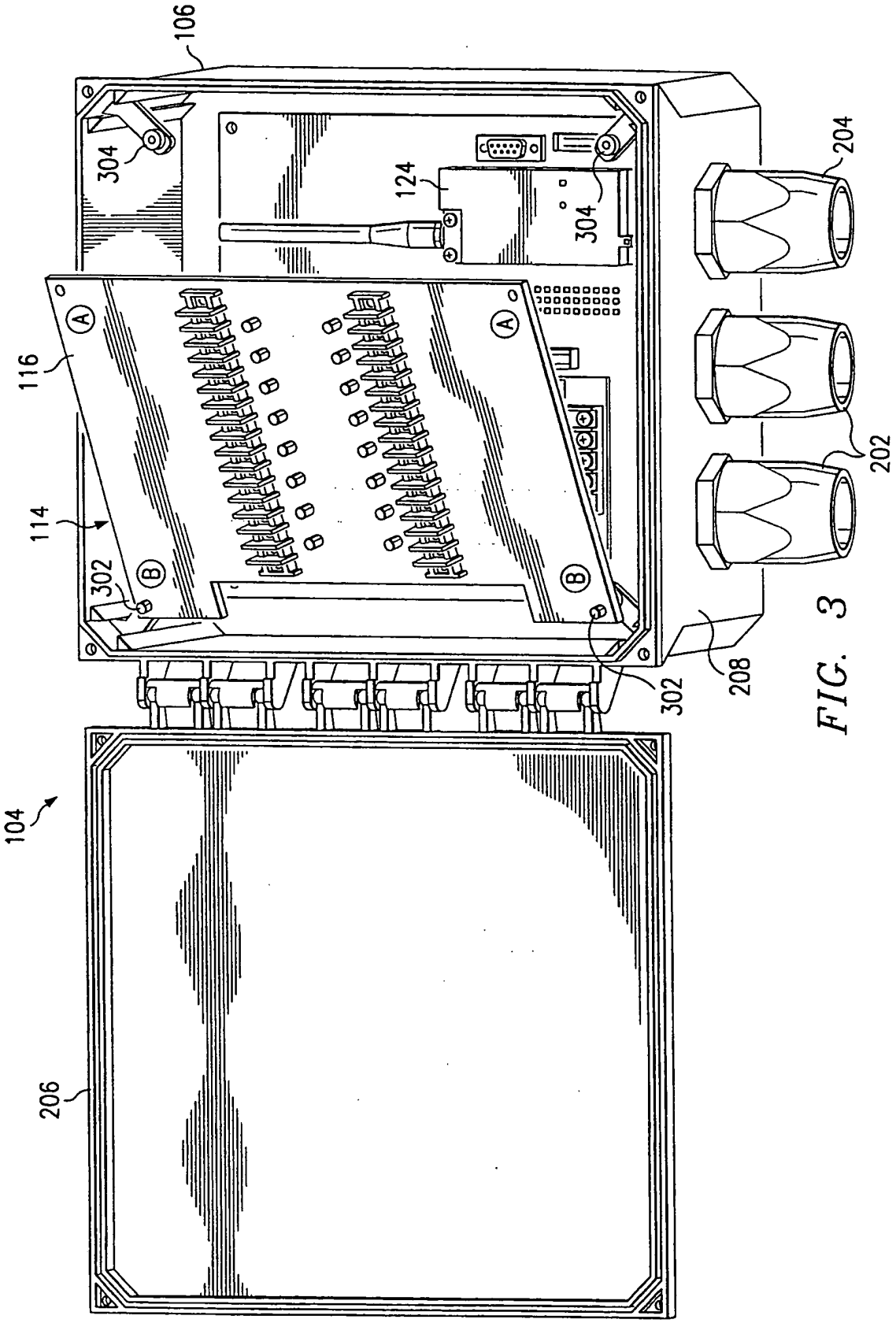


FIG. 3

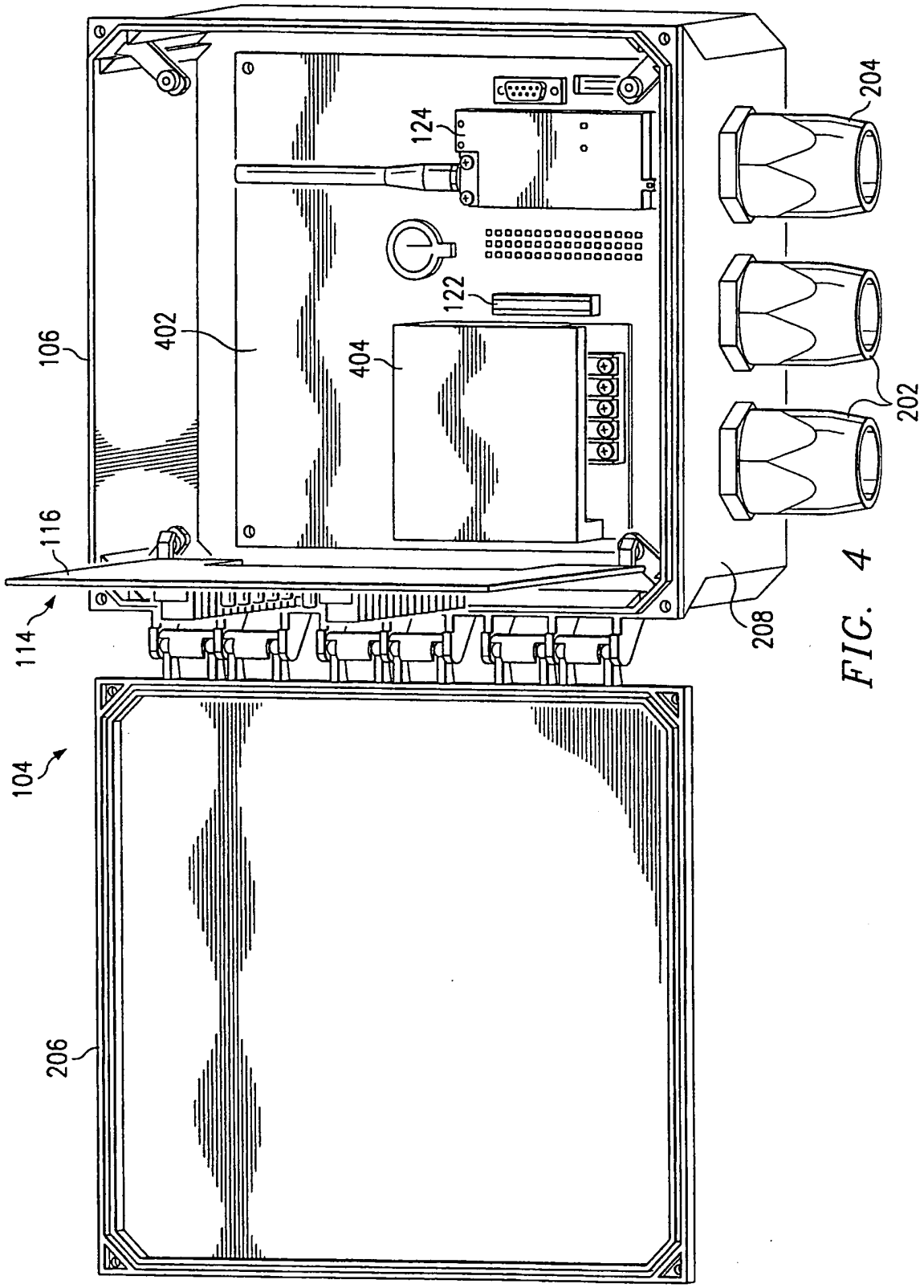
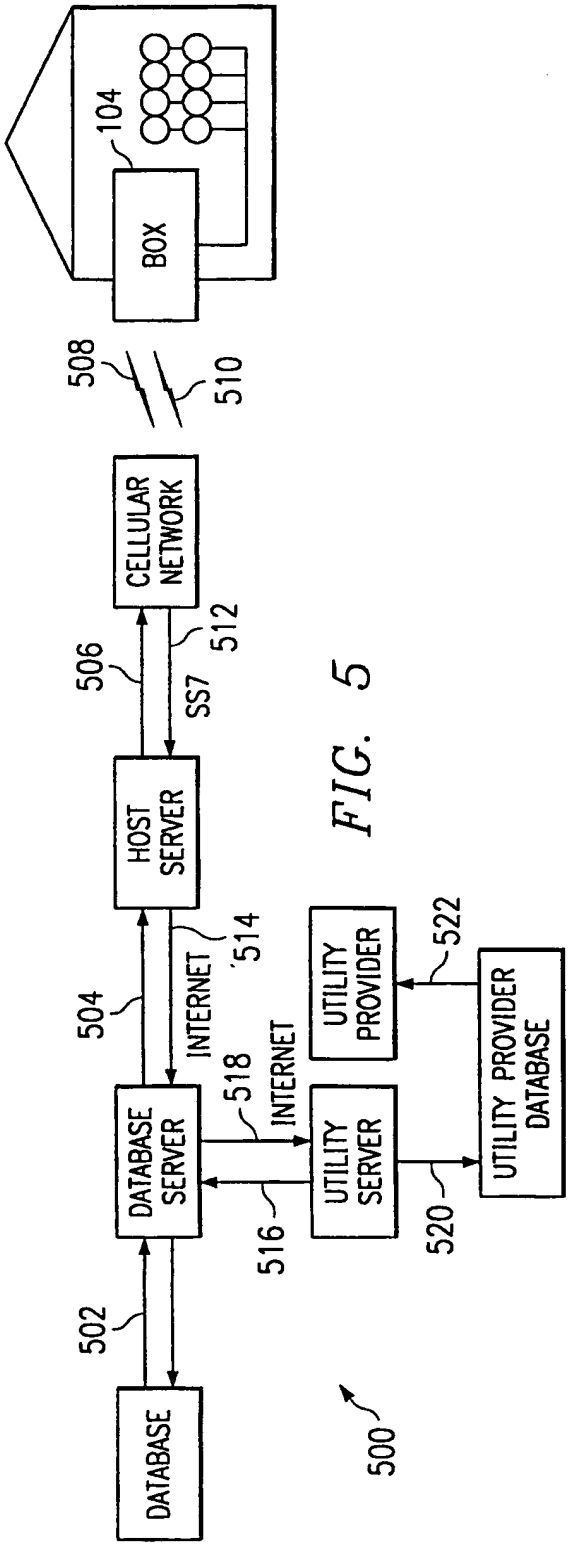


FIG. 4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BOX
508
510
CELLULAR NETWORK
506
SS7
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HOST SERVER
504
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DATABASE SERVER
518
INTERNET
UTILITY PROVIDER
522
UTILITY PROVIDER DATABASE
516
UTILITY SERVER
520
502
DATABASE
500

FIG. 5

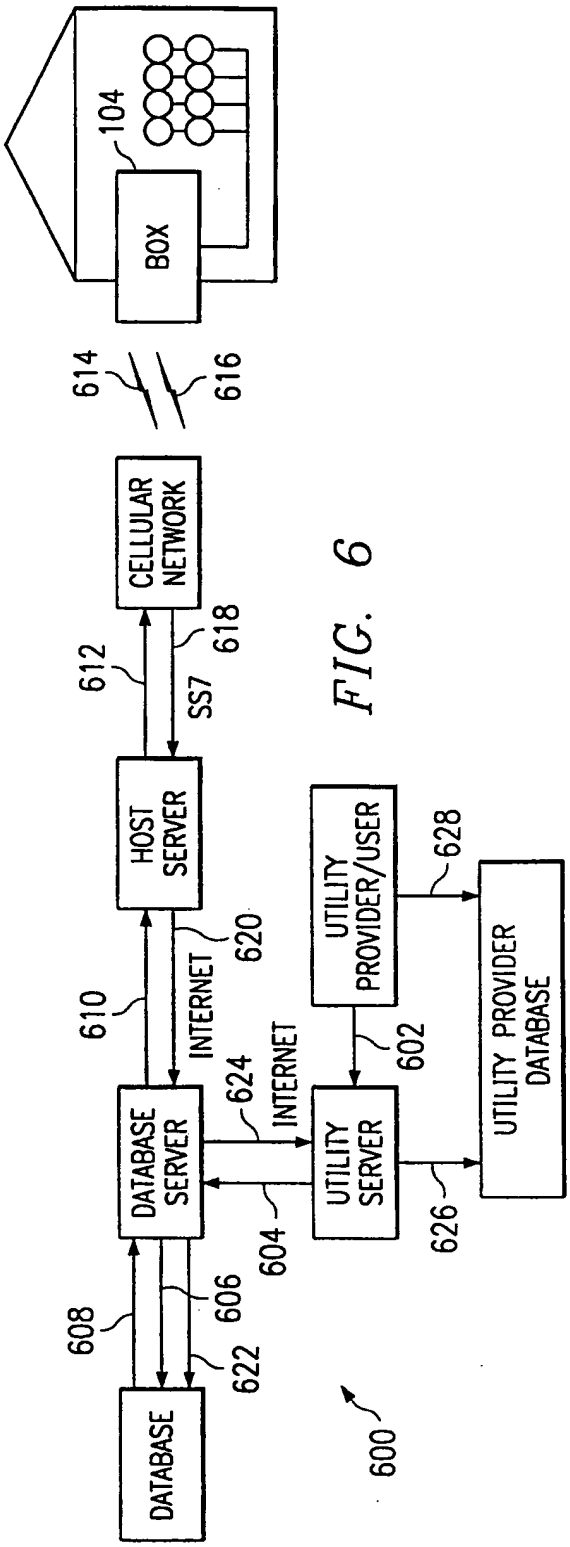
104
BOX
614
616
CELLULAR NETWORK
612
SS7
618
HOST SERVER
610
INTERNET
620
UTILITY PROVIDER/USER
628
602
DATABASE SERVER
624
INTERNET
UTILITY PROVIDER DATABASE
604
UTILITY SERVER
626
608
606
622
DATABASE
600

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/41568

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : Please See Extra Sheet.
US CL : 340/870.02, 870.03, 870.11; 379/106.03; 455/410, 414, 466

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 340/870.02, 870.03; 870.11; 379/106.03; 455/410, 414, 466

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST
search terms: control channel, cell, cellular, phone, meter, utility

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,E	US 6,150,955 A (TRACY et al) 21 NOVEMBER 2000, ALL	1-21
X,P	US 6,014,089 A (TRACY et al) 11 JANUARY 2000, ALL	1-21
Y	US 5,553,094 A (JOHNSON et al) 03 SEPTEMBER 1996, ALL	1-21
Y	US 5,594,740 A (LADUE) 14 JANUARY 1997, ALL	1-21
A	US 4,792,677 A (EDWARDS et al) 20 DECEMBER 1988, ALL	1-21
A	US A 5,801,643 A (WILLIAMS et al) 01 SEPTEMBER 1998, ALL	1-21
A	US 4,646,084 A (BURROWES et al) 24 FEBRUARY 1987, ALL	1-21

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 06 FEBRUARY 2001	Date of mailing of the international search report 05 APR 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer ALBERT WONG Telephone No. (703) 305-8884

Form PCT/ISA/210 (second sheet) (July 1998) ★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/41568

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (7):

G08B 23/00; G08C 15/06, 19/04, 19/10, 19/20; H04M 11/00, 1/66, 1/68, 3/16, 3/42